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APPLIED SCIENCE AND TECHNOLOGY POWAY CA
INTERAGENCY SOFTWARE EVALUATION GROUP COORDINATION AND MONITORING ETC(U)
AUG 79 R E NICKELL

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FINAL REPORT

CONTRACT N00014-79-C-0620, 8-1-79
TASK NO. NR 064-628/5/31/79 (474)

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1. Title of Research Effort. Interagency Software Evaluation
Group Coordination and Monitoring

Principal Investigator. Dr. Robert E. Nickell

2. (a) Key Words. Finite Element Methods
Software Evaluation
Nonlinear Dynamics
Elastic-Plastic Structural Response
Impact Analysis
~~Large Deformation~~

(b) Technical Objectives. The primary technical objective was to assure that the criteria for evaluation of the engineering software packages NASTRAN, ADINA, and STAGS were implemented by the individual evaluation contractors, and to review and monitor the evaluation activities. Several secondary objectives were also defined. These included a review and assessment of the use of large deformation, inelastic finite element programs--such as HONDO and DYNA3D--for design calculations; recommendations on flaw acceptance criteria for weldments in structures operating at elevated temperature; a description of the methods and procedures available to analyze low-velocity puncture of protective structures; and a fatigue assessment for offshore structures.

Applied Science & Technology,
Pomona, CA.

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3. Technical Approach. The Interagency Software Evaluation Group (ISEG) adopted a set of evaluation criteria developed by this investigator in a previous contract. These criteria were divided into those associated with documentation, programming, function, and performance. By using this subdivision approach to the evaluations, the research effort could be partitioned to experienced individuals in each area of specialty. For the secondary objectives, the approach was to apply modern analytical methods (advanced nonlinear finite element software) to the design of structures subject to extreme loadings--ranging from impact to puncture to elevated temperature to low-cycle fatigue. In this way, the efficacy of the application of this software to real nonlinear problems was assessed.
4. (a) Results and Conclusions--Current Research. The criteria developed for the ISEG evaluations seemed to work reasonably well. It was found that contractors tended to have difficulty handling the programming architecture description as third parties to the developer (first parties) and users (second parties). The programming description in the future should be limited to the items of data management, data base structure, and gross program flow. Greater emphasis should have been placed on the advanced evaluation exercises. For this reason, the criteria are to be subdivided into intrinsic evaluation criteria (documentation, programming architecture, and program functions) and extrinsic evaluation criteria (element library convergence, transient operator characteristics, eigensolution characteristics, nonlinear solution convergence, program efficiency, etc.). The term intrinsic is intended to cover those items that can be evaluated without intervention by the third party. Extrinsic refers to the evaluation exercises that involve active intervention by the third party.

Another result of the study was that two of the three codes, although used by a large number of Department of Defense laboratories, have minimal future potential. Less emphasis should be placed on current usage when selecting software for evaluation, with greater emphasis on future potential. A final result was the planning effort involved in the attempt to institutionalize this type of evaluation effort through a national engineering software center.

In the area of nonlinear analysis, the practical application of nonlinear, large deformation, elastic-plastic finite element software for both two-dimensional and three-dimensional simulations of impact, including the iterative design of closures, bolting, and protective shell containment, was demonstrated. Also, the use of such codes to derive information on puncture resistance of structures at low impact velocities was demonstrated.

- (b) Earlier Significant Accomplishments. Previous research efforts, in addition to the initial development of the criteria for the ISEG evaluations and the selection criteria for the software itself, concentrated on the principle of software auto-evaluation. This principle is becoming more widely adopted by the current generation of finite element software developers, who are writing pre- and post-processors to examine the user's mesh for condition and the user's results for such information as mesh effort. One of the earlier findings of this research was that the mesh effort was related to the strain energy projected onto the element deformation modes. When large amounts of energy are projected onto the higher element deformation modes, the solution obtained is not convergent.



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5. Abstract. The Interagency Software Evaluation Group effort has demonstrated that, with a modest revision of previously developed evaluation criteria to reflect intrinsic properties of the software and the extrinsic intervention of the third-party evaluator, a formal evaluation procedure has been demonstrated. In addition, advanced nonlinear finite element software has been shown to be capable of economic application to design problems related to impact and puncture resistance, elevated temperature response, and low-cycle fatigue evaluation.
6. Technological Significance. Industry has been made aware of the ISEG effort, with some firms using the evaluation criteria to justify engineering software procurement decisions. Software developers have found the evaluations particularly useful, since the formal criteria can be used for planning purposes. It would be hoped that the DOD would examine the findings of this research for their application to procurement of engineering software. The research on nonlinear finite element analysis has led some parts of industry, especially those concerned with the design of structural protection systems, to adopt a combination of analysis and testing (as opposed to testing alone) to verify design adequacy under extreme loadings. The DOD armor penetration community has expressed interest in the demonstrated modelling capability for low-velocity puncture.
7. (a) Technical Reports Distributed.
 1. "Large Deformation Inelastic Analysis of Impact for Shipping Casks", C.M. Charman, R.M. Grenier, and R.E. Nickell, Technical Report No. 1, Contract N00014-79-C-0620, Applied Science & Technology, August 1981.
 2. "The Interagency Software Evaluation Group: A Critical Evaluation of the ADINA, NASTRAN, and STAGS Structural Mechanics Computer Programs", Final Report, Contract N00014-79-C-0620, Applied Science & Technology, December 1981.

(b) Journal Articles and Books Published.

1. "Structural Mechanics Software Evaluation: A Bigeneric Diagnostic Framework", accepted for publication and to be published in the Structural Mechanics Software Series. (ONR Report)
2. "Design Rules for Containment Systems for Nuclear Spent Fuel and High-Level Waste Transport Packagings" (with K. Goldmann and R.H. Jones), in: Proceedings, PATRAM Conference, International Atomic Energy Agency, November 1980.
3. "Applications of Fatigue and Fracture Tolerant Design Concepts in the Nuclear Power Industry" (with R.L. Jones, T.U. Marston, S.W. Tagart, and D.M. Norris), in: Design of Fatigue and Fracture Resistant Structures, ASTM STP 761, ed. by P.R. Abelkis and C.M. Hudson, American Society for Testing and Materials, 1982.
4. "Large Deformation Inelastic Analysis of Impact for Shipping Casks" (with C.M. Charman and R.M. Grenier), accepted and to be published in Computer Methods in Applied Mechanics and Engineering, 1982. (ONR Report)

(c) Manuscripts Submitted For Publication.

1. "Scope and Elements of Weld Acceptance Criteria for Elevated Temperature Service" (with E.P. Esztergar), Symposium on Weld Acceptance Criteria for Elevated Temperature Service, ASME/PVP Conference, Orlando, Florida, June 28-July 1, 1982.
2. "Design of Radioactive Material Shipping Packagings For Low-Velocity Puncture Resistance", (with R. May), ARO Workshop on Computational Aspects of Penetration Mechanics, Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland, April 27-29, 1982.

8. Other Government Grants/Contracts. None
9. Personnel. Dr. Robert E. Nickell.
10. Honors, Awards, or Graduate Degrees. None.

